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AUTHOR Vacc, Nancy N.
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ABSTRACT

Differences between letters of four adolescent mildly mentally handicapped (MMH) students written by hand and those composed on a microcomputer using a word processor were examined in terms of amount of time a subject spent completing a letter, the length of a completed letter, the number of words written per unit of time needed to complete a letter, the number of revisions made while composng a letter, and the judged quality of a completed letter. Ss who had completed a typing course and had at least 1 year of experience using a microcomputer, were studied individually in a single-subject, repeated-measures, counter-balanced (i.e., crossover) design. Each S completed a total of 24 letters; 12 handwritten and 12 composed using a microcomputer. From the data analyses, it was concluded that the Ss spent significantly more time, produced noticeably longer letters, and made substantially more revisions when writing letters on a microcomputer than when completing handwritten letters. The mean number of words written per unit of time on task was substantially higher for subjects' handwritten letters than for their microcomputer-generated letters, which was attributed to the greater number of revisions made when completing letters on the microcomputer. Rater's evaluations of the quality of each letter, using holistic scoring criteria, revealed no difference between letters written on the microcomputer and handwritten letters. When selecting the five best letters written by each subject, however, the raters chose letters written on the microcomputer significantly more often than they selected handwritten letters. Charts and graphs are included. (Author/CL)

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Microcomputer Word Processor Versus Handwriting: A Comparative Study of Writing Samples Produced By Mildly Mentally Handicapped Students

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Nancy N. Vacc
Adjunct Assistant Professor
University of Florida
(904) 392-0755

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Abstract

Differences between letters of adolescent mildly mentally handicapped (MMH) students written by hand and those composed on a microcomputer using a word processor were examined in terms of amount of time a subject spent completing a letter, the length of a completed letter, the number of words written per unit of time needed to complete a letter, the number of revisions made while composing a letter, and the judged quality of a completed letter.

Four adolescent MMH students, who had completed a one-semester typing course and had at least one year of experience using a microcomputer, were studied separately in a single-subject, repeated-measures, counter-balanced (i.e., crossover) design. Each subject completed a total of 24 letters; 12 handwritten and 12 composed using a microcomputer.

From the data analyses, it was concluded that the subjects spent significantly more time, produced noticeably longer letters, and made substantially more revisions when writing letters on a microcomputer than when completing handwritten letters. The mean number of words written per unit of time on task was substantially higher for subjects' handwritten letters than for their microcomputer-generated letters, which was attributed to the greater number of revisions made when completing letters on the microcomputer. Raters' evaluations of the quality of each letter, using holistic scoring criteria, revealed no difference between letters written on the microcomputer and handwritten letters. When selecting the five best letters written by each subject, however, the raters chose letters written on the microcomputer significantly more often than they selected handwritten letters.

Teaching written communication to adolescent mildly mentally handicapped (MMH) students poses great difficulty for many teachers. Because many adolescent MMH students previously have encountered difficulty in handwriting, spelling, usage, and written expression, they try to avoid writing in general, losing sight of the function of writing as a communicative process (Morsink, 1984). In addition, MMH students often complete assignments by writing the minimum amount necessary (Hall, 1981), therefore spending insufficient time with the task to acquire greater proficiency. Consideration needs to be given to instructional techniques that will maintain MMH students' interest in writing and extend the time they spend on writing assignments, thus enabling them to strengthen the written-communication skills needed for functioning independently after leaving high school.

One possible writing-instruction technique is to complete written assignments on a microcomputer word processor. The special benefit of using computers to help students with activities that they find difficult, especially writing, was stressed by Papert (1981), who indicated that students have more reason to write with a computer: they can produce exciting effects on the computer screen, have control over a machine, and are engaged in what is considered an adult activity. The value of using computers in education was also supported by Cain (1984) and by Jamison, Suppes, and Wells (1974), who stated that of all the methods of instruction that have been developed, computers provide the richest and most highly individualized interaction between student and curriculum.

Using a microcomputer to complete written assignments would appear to have several advantages. First, it can provide the reinforcement that many MMH students need to encourage them to spend more time on a writing assignment. The knowledge that a writing assignment could be composed and edited on a microcomputer and a final product completed without having to rewrite it by hand--a laborious task for many MMH students--can be sufficient reinforcement to generate and maintain longer on-task behavior, and provide more opportunity to develop writing proficiency. Composing with a microcomputer word processor can also be advantageous because typing appears to be an easier activity for many MMH students than is handwriting (Howe, 1983), and revisions can be made more easily through deletions, insertions, and/or reordering of text stored in the computer, with immediate feedback provided on the changes.

Although the number and use of microcomputers in United States schools are increasing, and word processors are purported to be valuable instructional aids for developing writing skills, there is, however, no firm empirical basis to support their use in writing instruction or their effectiveness as instructional tools with adolescent students.

Purpose of Study

The present research was undertaken in a public-school environment, to study the differences between letters adolescent MMH students wrote by hand and letters they composed on a microcomputer using a word processor. The dependent variables of interest were time on task (i.e., number of minutes a subject spent completing a

letter), length of letter, an index that indicated the number of words per unit of time on task for each letter completed, number of revisions per letter, and judged quality of the letter. Letter writing was selected as the task to be completed by subjects because it is a basic skill that needs to be developed if students are to function independently in adulthood, it provides a meaningful purpose for writing, it generates a realistic audience, and it is one of the "uses" of writing emphasized in the writing curriculum.

METHOD

Subjects

One white and three black male students attending a junior-high school in central North Carolina served as subjects in the experiment. The four subjects were eighth-grade students who had been certified as mildly mentally handicapped (MMH) under the guidelines of North Carolina ("Rules Governing Programs," 1978), had been enrolled in a special education program for at least two years prior to the study, ranged in age from 14 years 11 months to 15 years 5 months, were enrolled in a learning-resource room program at the time of the study, and had completed a one-semester course in typing. All subjects had experienced using an Apple IIe microcomputer in their learning-resource classroom for at least one year and were experienced in using the word-processing program Bank Street Writer. Three subjects had achieved a full-scale performance score on the WISC-R of 72; the fourth subject's full-scale score was 65.

Treatments

The treatments used in the study were writing letters by hand and writing letters using a microcomputer word processor (Wordstar on

an Osborne microcomputer). The researcher met individually with each subject in a reading room of the school library for a maximum of 45 minutes per letter-writing session. The subjects participated in the study during the class period when they were scheduled for language arts; the completed letters were used in partial fulfillment of their language-arts objectives. The letters assigned were semi-self-directed and open-ended, since their content depended on the respective writer's interests, experience, knowledge, and environmental background. All sessions were videotaped, which provided direct but nonintrusive observation and permitted detailed measurement of each subject's progress.

To minimize the threat to internal validity that might result from having qualitatively different instructions associated with each treatment, parallel sets of standardized instructions were developed for the subjects to use when editing handwritten letters and when editing letters completed on the microcomputer. The instructions were presented during the pre-session when the study was introduced to the subjects and the basic requirements of letter writing (i.e., form, spacing, and content) were reviewed. Separate charts listing the instructions were also placed in front of a subject for his reference when needed during a handwriting or computer session.

At the beginning of each session, a subject was assigned a letter to write with its purpose and directions typed on a 5" by 8" card. The subject was asked to read the directions silently while the researcher read them aloud. The writing task was started after the subject indicated that he understood the purpose of the

assignment and knew to whom he would write the letter. The subject was instructed to raise his hand when finished.

Letter length was determined by tabulating the total number of words in a completed letter. A word-per-minute index, the number of words per unit of time on task, was computed as the ratio between the number of words in a letter and the number of minutes a subject spent completing that letter. The number of revisions per letter consisted of the total number of changes a subject made while writing a letter. Letter quality was determined by four raters using holistic scoring criteria.

Instrumentation

Data for analyzing the characteristics and quality of the letters were derived from analyses of the videotapes, a review of each letter, and teacher evaluations of each letter.

Videotapes. The videotapes were coded by the researcher to verify the number of minutes each subject spent completing each letter and to determine the number of changes or revisions made in each letter by each subject. The timing of a session began with the subject's first pencil stroke or with the first letter struck on the microcomputer keyboard. The end of the time-on-task period was recorded as the time when the subject raised his hand showing that the letter was completed.

The number of revisions made during each letter-writing session was determined during the videotape analyses by recording each time a letter, word, or line was changed in one of the following ways: deleted without replacement, deleted with replacement, or inserted.

Completed Letter. The number of words per letter was counted and recorded. Because each subject's typing and handwriting proficiencies were not equivalent, a words-per-minute index was calculated for each letter by dividing the number of words in the letter by the time needed to complete that letter.

At the conclusion of the study, four teachers who were certified to teach English in sixth through ninth grade in North Carolina, evaluated the quality of each letter using the holistic scoring criteria recommended by Tiedt (1983). To prepare the four raters, a training session was conducted using letters completed by eighth-grade MMH students who attended a different school in central North Carolina. A mean inter-rater agreement index (Medinnus, 1976) of 0.85 was achieved after the tenth letter was evaluated, and the training session was concluded.

The subjects' handwritten letters were reproduced verbatim at the conclusion of the study, using the microcomputer and printer. Thus, all letters were produced in the same manner and the raters did not know whether an original letter was handwritten or completed on the microcomputer. Using Tiedt's scale, the teachers rated each letter independently on a scale from one to nine, based on the characteristics they felt best described the letter's overall quality. In addition, each rater selected the five best letters for each subject, as suggested by Gould (1981).

Design

A single-subject, repeated-measures, counter-balanced (i.e., crossover) design with intersubject replication was used in the study, resulting in two treatment formats: an HCHC treatment

sequence (used by two subjects), and a CHCH treatment sequence (used by two subjects) where "H" was the handwritten-letter treatment and "C" was the treatment consisting of letters completed using a microcomputer word processor. The baseline measures, to which the treatments that followed in sequence were compared, were defined by recording the number of minutes a subject spent completing an assigned letter. Baseline stability (Tawney & Gast, 1984) for all four subjects was reached at the end of six sessions, which determined phase length. Each subject completed a total of 24 letters; 12 handwritten and 12 using the microcomputer word processor.

Twelve different letter-writing purposes with practical value were employed: file a complaint, request an application, request a service, request information, provide a set of directions, share a point of view, apply for a membership, relate an experience, share news with a friend or relative in another city, place a mail order, express appreciation, and state an argument against something. Two similar sets of letter-writing assignments (designated a and b) were developed for each purpose. The order for presenting the letter-writing purposes was determined by using a table of random numbers. By reversing the a and b letter-writing assignments for each purpose, four different treatment formats were developed and a subject was randomly assigned to each. Subject 1 (following the HCHC format) and Subject 3 (following the CHCH format) completed Set a during the first and third treatment phases and Set b during the second and fourth treatment phases. Subject 2 (following the HCHC format) and Subject 4 (following the CHCH format) completed Set b during the

first and third treatment phases and Set a during the second and fourth treatment phases.

Analytic Procedures

The data derived from behavioral counts using the video recordings of sessions, tabulations using the completed letters, and quality judgments of the raters, were analyzed using the descriptive procedures of the Statistical Analysis System (SAS) computer package (Ray, 1982) and the plotting procedures of the Statistical Package for the Social Sciences (SPSS) computer program (Hull & Nie, 1981).

The data were also analyzed by computing effect sizes (Glass & Hopkins, 1984) for each dependent variable, to determine the magnitude of mean differences when treatment mode was changed, compared to the average standard deviation within each treatment mode. Three effect sizes were computed for each subject, per dependent variable. The first reflected the mean change between Phase Two and Phase One, the second the mean change between Phase Three and Phase Two, and the third reflected the mean change between Phase Four and Phase Three.

RESULTS AND DISCUSSION

The results of the data analyses are presented in five sections: time on task, length of letter, total number of revisions, words-per-minute index, and quality of letter.

Time on Task

Graphic data illustrating the number of minutes spent by each subject completing the 24 letters are presented in Figure 1. The subjects' mean times per letter for each treatment phase are graphically illustrated in Figure 2. All four subjects spent

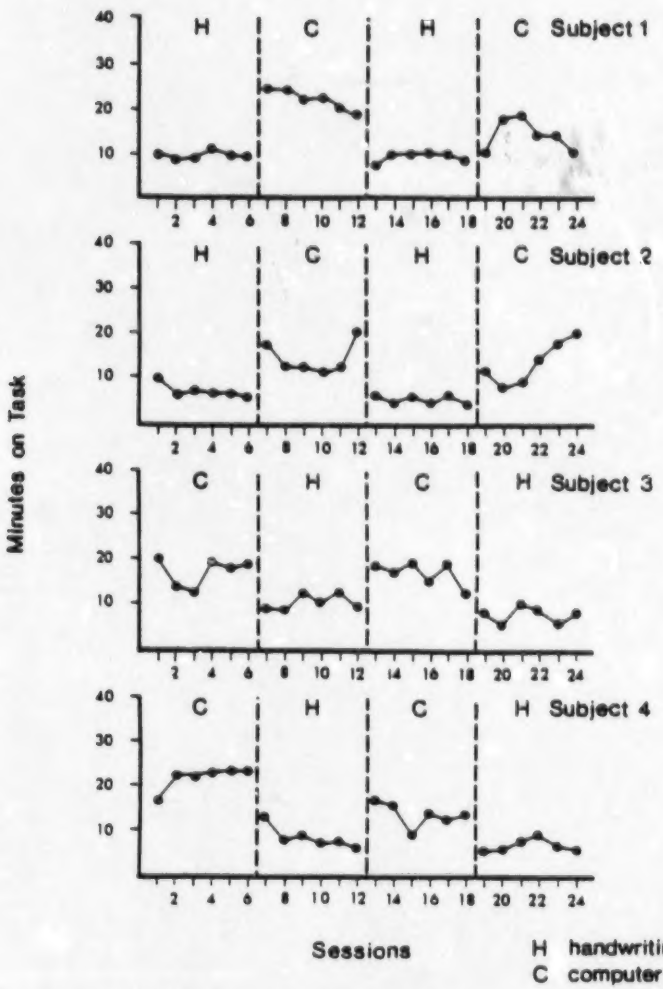

Figure 1. Number of minutes on task per session, for each subject.

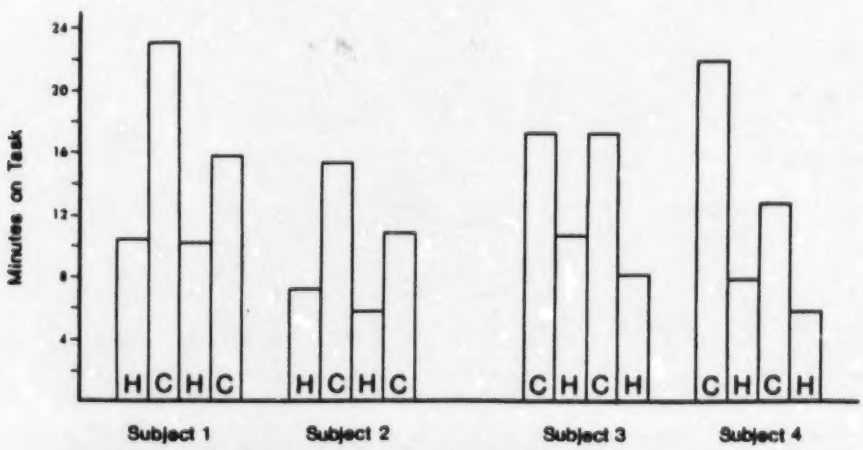

Figure 2. Mean number of minutes on task per letter, by treatment phase, for each subject.

substantially more time completing letters on the microcomputer than they did completing handwritten letters, regardless of treatment-order sequence or the order of presentation of paired letters. This is supported by the effect sizes presented in Table 1. The difference between the mean number of minutes subjects spent writing letters on the microcomputer and writing letters by hand was greater when the microcomputer task was presented first in the treatment sequence. But regardless of sequence of presentation, mean differences between times on task substantially exceeded the average variability of time on task within a treatment phase.

For all subjects there was a significant positive relationship (see Table 2) between time on task and two other relevant variables: total number of revisions and length of letter. All subjects made a greater number of revisions in their microcomputer-generated letters than they did in their handwritten letters and completed longer microcomputer-generated letters than handwritten letters, thus requiring more time on task.

Finally, Figures 1 and 2 illustrate that, with two exceptions, each subject's mean time on task was lower for the second application of a given treatment than for the first application. The general decrease in mean number of minutes spent completing letters, from the first application of a treatment to the second, could be attributed to the subjects' increased practice in letter writing; as subjects gained experience in writing letters, the amount of time they needed to complete an assigned letter decreased.

Table 1

Effect Sizes For Each Dependent Variable by Treatment Mode

Variable	Effect Size H-C Treatment*	C-H Treatment*
Time on task	-2.86	4.05
Words per letter	-1.14	1.01
Number of revisions	-1.92	2.41
WPM index	-1.87	3.03
Letter quality	.62	.43

* H-C is shift from handwriting to computer
  C-H is shift from computer to handwriting

Table 2

Correlations Between Words-per-minute Index (WPM), Number of Revisions (Revisions), Number of Minutes On Task (Time), Length of Letter (Words), and Quality of Letter (Quality), by Subject

	Variables			
Subjects and Variables	WPM	Revisions	Time	Words
Subject 1				
Revisions	-.3455*			
Time	-.8190**	.6137**		
Words	.1104	.1234	.4123+	
Quality	-.2160	.2341	.3991+	.4615+
Subject 2				
Revisions	-.3836*			
Time	-.8708**	.7732**		
Words	-.2782	.6683**	.3690*	
Quality	.2020	-.0943	-.1767	-.0298
Subject 3				
Revisions	-.3883*			
Time	-.8400**	.7999**		
Words	-.1783	.6118**	.6120**	
Quality	.0197	.1900	.1516	.2943
Subject 4				
Revisions	-.6952**			
Time	-.8047**	.8300**		
Words	-.1582	.4580**	.6223**	
Quality	-.2555	.4608+	.5086*	.6078**

+ p < .05
* p < .01
** p < .001

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Number_of_Words_per_Letter

As graphically illustrated in Figures 3 and 4, each subject wrote longer letters when using the microcomputer to complete assignments than when completing letters by hand, regardless of treatment-order sequence or the order of presentation of paired letters. Although the effect-size data, as presented in Table 1, were not as striking for average letter length as they were for time on task, differences between treatment means that approximate the average within-treatment standard deviation are usually regarded as being substantial (Glass & Hopkins, 1984).

The data in Table 2 indicate that, for all subjects, the number of words written per letter is highly correlated with the amount of time spent completing a letter. This result was expected. For Subjects 2, 3, and 4, the data also indicate a significantly positive relationship between the number of words written per letter and the number of revisions made per letter; more revisions were associated with longer letters.

As Figures 3 and 4 illustrate, the mean number of words per letter written by subjects varied between the first and second applications of a given treatment. For the microcomputer-treatment sessions, Subjects 1 and 2 averaged a similar number of words per letter during the first and second treatment applications; Subject 3, on average, wrote longer letters during the second treatment application than during the first application; and Subject 4 decreased his mean number of words per letter during the second application of the microcomputer treatment. With the handwriting treatment, Subject 1, on an average, wrote longer letters during the

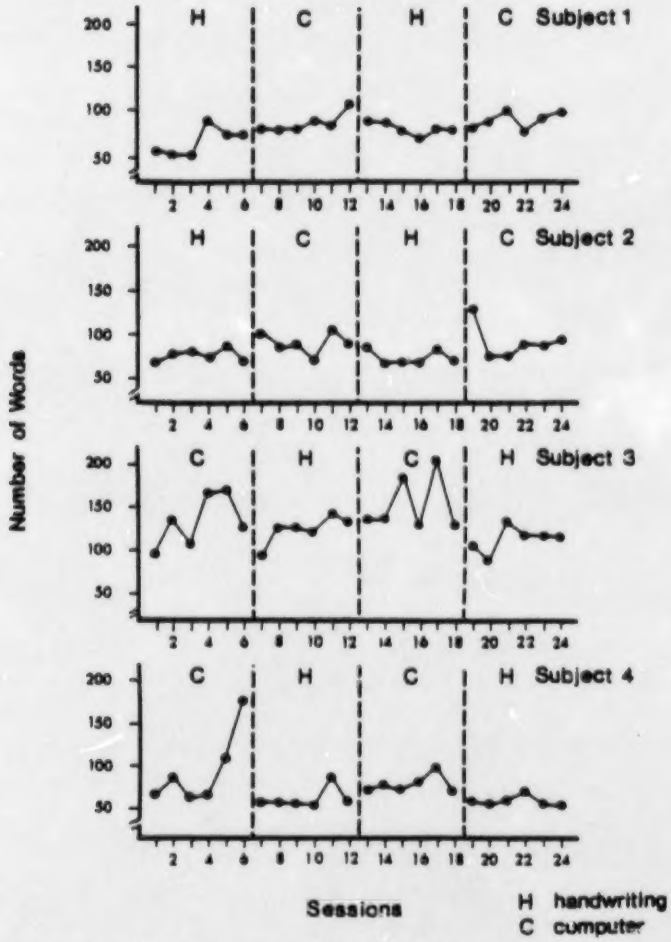

Figure 3. Number of words per letter, by session, for each subject.

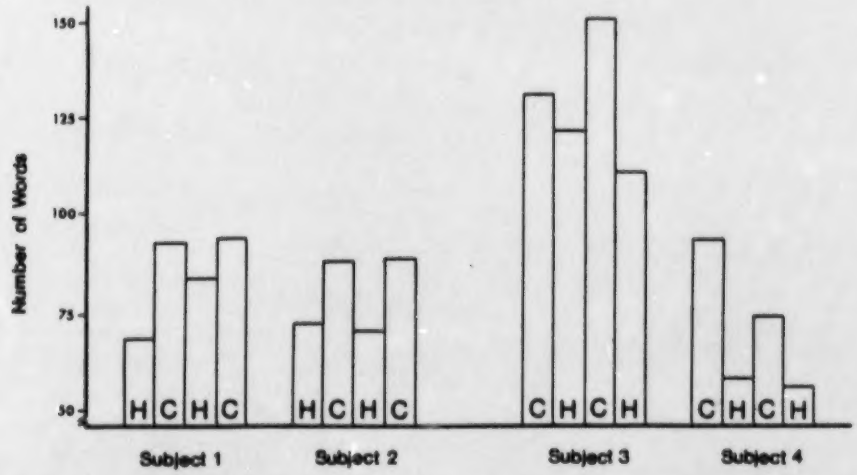

Figure 4. Mean number of words per letter written by each subject, by treatment phase.

second treatment application than during the first application, and Subjects 2, 3, and 4, wrote shorter letters during the second treatment application than during the first application. However, differences between the mean number of words per letter were minimal for Subjects 2 and 4. Variation in the lengths of letters appears to be attributable to individual differences between subjects, or to a factor not considered in this study.

Total Number of Revisions

The data presented graphically in Figures 5 and 6, indicate that each subject averaged significantly more revisions in letters when using the microcomputer than when writing letters by hand, regardless of treatment-order sequence or the order of presentation of paired letters. Mean differences between the average numbers of revisions made by the subjects substantially exceeded the average variability of the number of revisions they made within a treatment phase (see Table 1).

For all subjects, the number of revisions made per letter was highly negatively correlated (see Table 2) with the index of number of words written per minute; as subjects made more revisions in their letters, the number of words written per minute on task decreased. The majority of revisions made in all letters were deletions with replacements. Deletions without replacements included either letters at the ends of words to change tense or to change to singular form, or words at the beginning of a new phrase, whereby the subject ended the sentence at that point.

There were observable differences among subjects in the amount of revising they undertook. Subjects 3 and 4 made considerably more

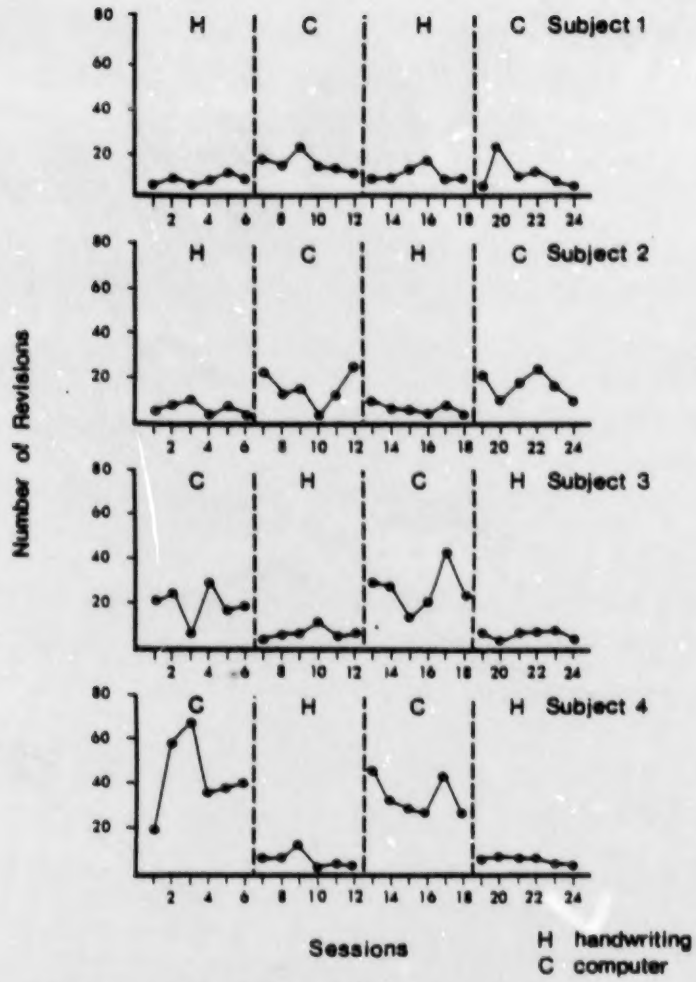

Figure 5. Number of revisions per letter made by each subject, by session.

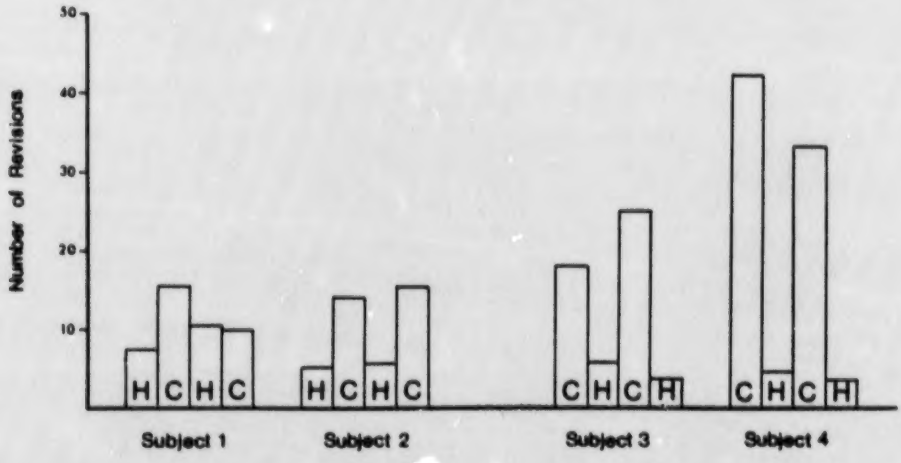

Figure 6. Mean number of revisions per letter made by each subject, by treatment phase.

revisions in their microcomputer-generated letters than did Subjects 1 and 2, but there seems to be no clear justification for the differences between their performances. The videotape analyses indicated that Subjects 1 and 3 periodically read what they had written as they progressed through each assignment and usually re-read their completed letter before signaling that they were finished with the assignment. On two different occasions, Subjects 1 and 3 each deleted a word and replaced it with another word after re-reading a letter completed on the microcomputer. In contrast, Subjects 2 and 4 usually did not read their completed letter before signaling that they were finished with the assignment, nor did they, when finished, return to a previously written sentence to make a revision. Differences between the revising activities of the four subjects could be attributed to individual variations in writing-process components, a factor that was not considered in this study.

Words-per-minute Index

For all subjects, the average number of words written per minute with handwritten letters was substantially higher than the average number of words written per minute when completing letters using a microcomputer word processor, regardless of treatment order or order of presentation of paired letters (see Figures 7 and 8 and Table 1).

The difference between the mean number of words written per minute during each writing mode could be explained by the number of revisions made when completing letters. As shown in Table 2, for each subject there was a significant negative correlation between number of words written per minute and total number of revisions;

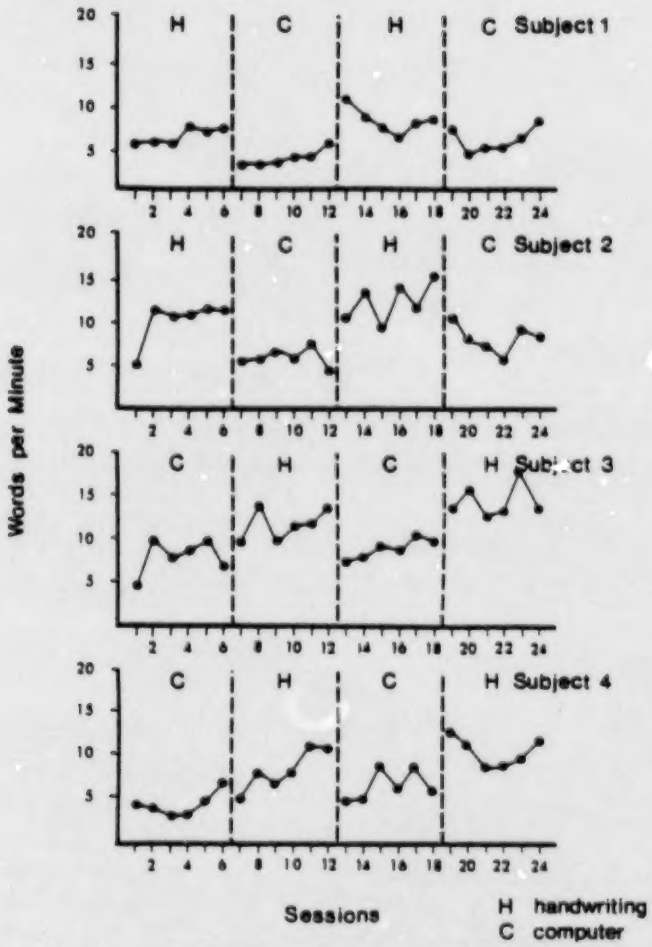

Figure 7. Number of words written per minute by each subject, by session.

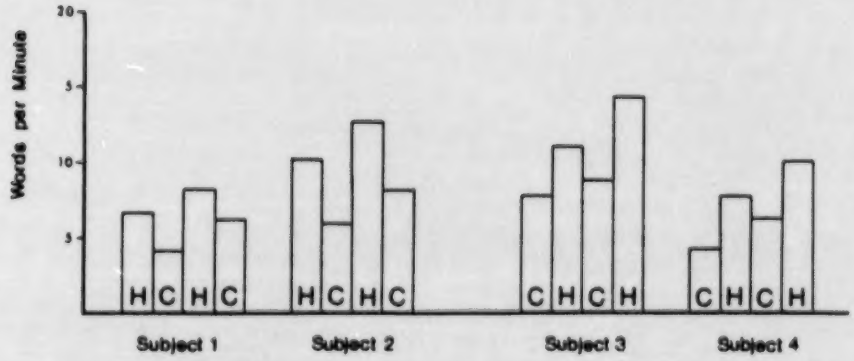

Figure 8. Mean number of words written per minute by each subject, by treatment phase.

the greater the number of revisions made while completing an assigned letter, the fewer the words written per minute. Because all subjects made more revisions when using the microcomputer, the number of words they wrote per minute was substantially lower for their microcomputer-generated letters.

Figures 7 and 8 indicate an increasing trend in the number of words written per minute by each subject across sessions and treatments. These data suggest that, as the subjects increased their letter-writing experiences, they wrote more words per minute. This finding is consistent with Bloom's (1974) statement that the combination of longer time on task and favorable learning conditions promotes more efficient student learning.

Quality of Letter

The holistic scores assigned to a letter as the four raters evaluated a subject's 24 writing samples were averaged to obtain a mean quality score for each letter. No difference was found between the average holistic score assigned to letters written using the microcomputer and the average holistic score assigned to letters written by hand (see Figures 9 and 10 and Table 1).

Table 2 illustrates that Subject 1 received higher holistic scores on longer letters and on letters that took more time to write. Similar results were found for Subject 4, who also received higher holistic scores for letters that contained a greater number of revisions during their completion. In contrast, Subject 2 received higher holistic scores on letters that took less time to complete, had fewer words, and contained fewer revisions.

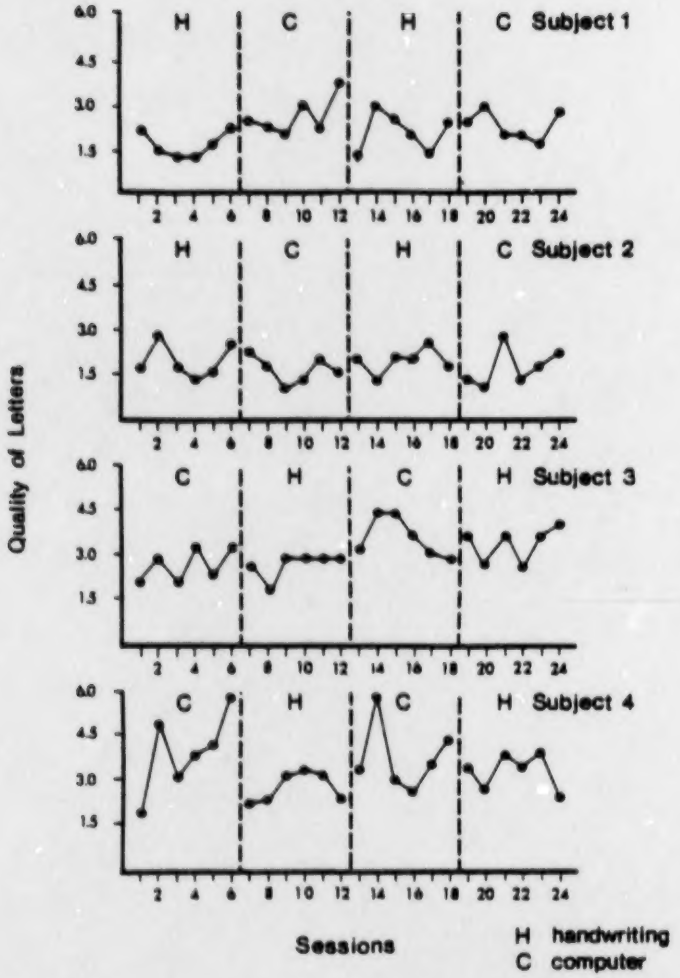

Figure 9. Mean holistic score assigned to each letter, by subject and session.

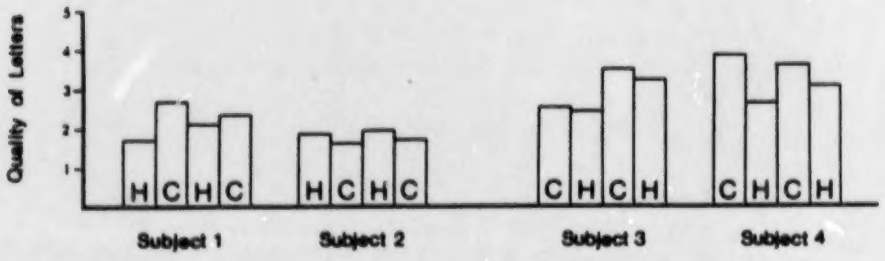

Figure 10. Mean holistic score assigned to letters of each subject, by treatment phase.

In addition to evaluating subjects' letters using holistic-scoring criteria, each rater selected the five "best" letters completed by each subject. For all subjects, microcomputer-generated letters were selected by the raters as "best letters" approximately twice as often as were handwritten letters (χ^2 = 18.00 with 3 degress of freedom; p (.005).

The difference in outcomes resulting from the two quality-assessment techniques (i.e., holistic-scoring criteria and teachers' judgments of best letters) cannot be explained with certainty. The difference might be attributed to the nature of the judgment tasks performed by teachers when they used Tiedt's scale and when they selected the letters that were "best." Tiedt's scale required that each letter be rated against a specific set of criteria. Selection of the "best" letter was essentially a ranking task, without constraints on the criteria used to judge one letter as being better than another. The latter strategy, by its normative nature, might more validly reflect the differential quality of writing samples produced by subjects who are homogeneous in their writing abilities (e.g., MMH students).

CONCLUSIONS

The results of this study indicate that writing on a microcomputer generates and maintains longer on-task behavior, provides more opportunity to develop writing proficiency because of the ease with which revisions and additions can be made in a writing sample, provides greater opportunity to develop writing proficiency, and appears to increase writing quality.

The data analyses in this study determined that a microcomputer word processor is an effective instructional tool for aiding in the development of MMH students' writing skills. It affected students' written responses by increasing the amount of time spent on writing assignments, increasing the number of revisions they made during writing tasks, and extending the length of completed assignments. Also, microcomputer-generated letters were selected significantly more often when raters chose the five best-quality letters completed by a subject.

The outcomes of this study are similar to those found by Gould (1981) in his comparative study of adults' handwritten letters and letters they composed using computer-based text editors. The findings of this study are also consistent with previous research that found computer-assisted instruction to be effective with adolescent students achieving below grade level (Jamison, Suppes, & Wells, 1974) and with low-ability students in first through sixth grades (Suppes & Morningstar, 1969).

The results of this study might be explained by the three major elements of the act of writing, as outlined by Flowers and Hayes (1981): the task environment, the writer's long-term memory, and the writing processes of planning, translating, and reviewing.

The task environment encompasses everything around the writer, including the writing sample being developed. When the task environment included a microcomputer, the subjects might have been more actively engaged in their writing experiences, or they might have been provided with more visual-motor and kinesthetic-tactile experiences, instructional strategies needed by many MMH students for

efficient learning (Hallahan & Kaufmann, 1982; Hammill & Bartel, 1978; Morsink, 1984).

According to Flower and Hayes (1981), the writer's long-term memory exists in the mind as well as in outside resources such as books. Long-term memory affects the development of a writing sample because the writer must find a cue for retrieving specific knowledge to apply to the task, and then reorganize or modify that information to fit the needs of the writing task. The ease with which letters, words, and lines could be inserted or deleted when composing on the microcomputer, might have allowed more opportunity for the subjects in this study to search for cues that would aid recall of specific information to be used in modifying the content of a letter and to adapt retrieved information to fit the purpose of the writing assignment, thus affecting the time spent completing a letter on the microcomputer, the length of letters composed on the microcomputer, and the number of revisions made.

The lack of a significant difference in the holistic scores assigned to letters written by hand and those composed on microcomputer, might be explained by the homogeneously low abilities of the subjects studied. The four MMH students who served as subjects in this study were achieving below grade level in language arts. Therefore, the holistic scores assigned their letters tended to cluster near the lower end of the rating scale, with little variation in scores.

The subjects in this study completed fewer words per minute on task when composing letters on a microcomputer than when composing handwritten letters. Although this outcome was attributed to the

greater number of revisions made by all subjects in microcomputer-generated letters, it also could have been affected by the subjects' proficiency in handwriting skills compared to their typing skills. All subjects had been introduced to typing within six months to one year prior to the commencement of the study and, therefore, their typing skills may not have been as well developed as handwriting skills.

Limitations

The findings of this study might not generalize to handicapped students who are enrolled in other learning-resource programs (e.g., those for moderately mentally handicapped or learning-disabled students). Caution is also recommended in applying these results to adolescent female MMH students because of possible differences in writing ability between males and females (Barbig, 1969; Maloney, 1968); possible sex differences on dimensions related to academic success such as spatial and verbal task differences (Ackerman, Dykman, & Oglesby, 1983; Maccoby & Jacklin, 1974); and formal operational task differences (De Hernandez, Marek, & Renner, 1984).

All subjects had used a microcomputer for at least one year prior to the initiation of the study, and had completed a one-semester course in typing. The results of this study might not be applicable to MMH students who do not have similar typing skills or have not had comparable experience using a microcomputer.

Finally, it should be noted that three of the four subjects were black. To the extent that race of subject interacts with the difference between the judged quality of letters written on a microcomputer and letters written by hand, the results of this study might not generalize to populations of other racial composition.

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